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Evolution of progradation/erosion along the French Guiana mangrove coast: a comparison of mapped shorelines since the 18th century with Holocene data

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Abstract

The problems in mapping the mangrove shoreline of French Guiana are reviewed. The present variability of the coastline due to the shifting mudbanks with *Avicennia* mangroves on their shoreface-attached upper fringe is extended to the historical period two and a half centuries ago, by means of ancient maps and nautical charts. In selected sites (around the Sinnamary River and the Mana River estuaries, Cayenne Peninsula) the earliest reported shoreline (before 1765), compared with other 18th and 19th century maps, is relatively stable, demonstrating that erosion repeatedly counterbalanced progradation on a centennial time scale. This data contrasts with the 20th century initiation of a sedimentary regime that results in very high local progradation rates. An examination of the entire Holocene sediment record in preserved in French Guiana, including palynological evidence, suggests that most of the Holocene progradation may have occurred by different accretion processes than have formed the historical and recent mudbanks settled by *Avicennia* mangals.

Keywords: French Guiana; sedimentology; mangrove; Holocene; historical maps; progradation rates

1. Introduction

The muddy coast of French Guiana is presently subject to rapid changes in shoreline position. These are produced by alongshore mudbank migration as illustrated by consecutive editions of the detailed maps of the French Institut Géographique National (IGN), based on aerial photographs, and underlined by the Atlas of the French Department of Guiana (Boyé et al., 1979; Fig. 1). Shoreline mapping of this region has to overcome a number of difficulties that are inherent in the nature of local mangrove colonization. One problem is the accurate location of the shoreline where a transition zone of mature mangroves grades inland to freshwater swamps. Another problem is the extensive annual variability in the seaward mangal (mangrove forest) extension, which leads to rapid map obsolescence.

New technologies, such as GIS mapping of aerial photographs and satellite imagery including radar (Baltzer et al., 1994), have created new possibilities for accurate mapping. At the same time, they have enhanced our knowledge of the sedimentological processes that control coastal evolution. For periods prior to the mid-20th century, historical maps have been

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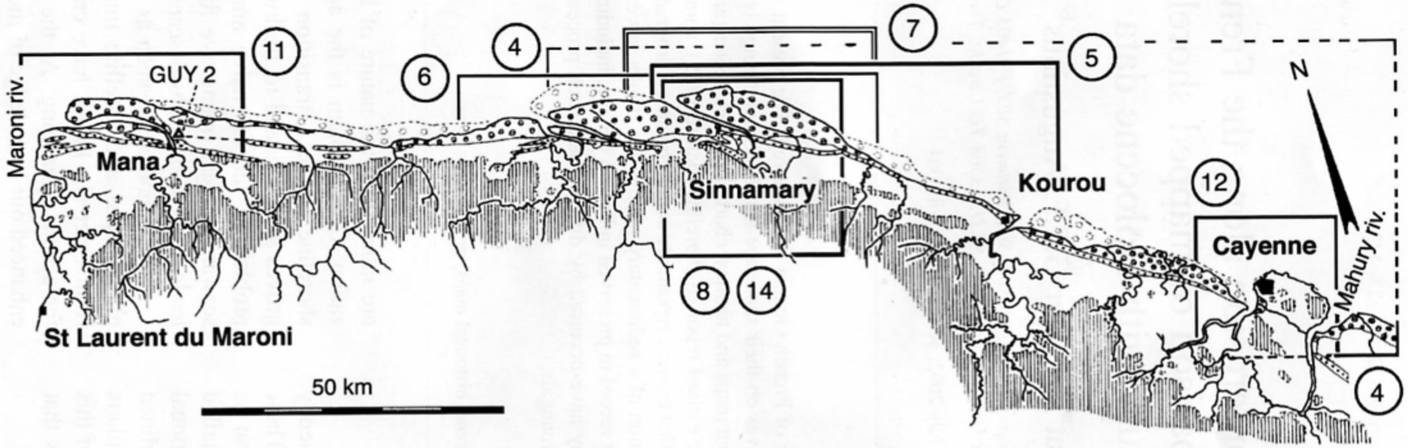

Fig. 1. The coastal plain of French Guiana, between the Mahury and Maroni rivers. Higher lands are limited by vertical hatches. The white belt is mostly referred to as Holocene deposits. Discontinuous dotted stretches indicate chenier sands. The mangroves (circles) illustrate the 1965 shoreline (solid line) and earlier, post-1940 mangrove extensions (discontinuous). After the 1979 Atlas of French Guyana. GUY 2: Location of the core giving a palynostratigraphy of the local Holocene deposits. (4–14): Location of the modern and historical shoreline representations in Figs. 4–14.

made available recently by historical researchers (Puaux and Philippe, 1997). From the point of view of sedimentology, these maps are a previously ignored, but promising source of information about coastal evolution along the Guianas coast, extending back more than two centuries. The first objective of the present study is to examine the possible contribution of a few historical maps of French Guiana that were deemed most accurate, following a critical examination of a larger map database. It will be demonstrated that the process of shoreline change associated with mudbank migration presently at work was active during the entire historical period. We will also discuss the implications for earlier times in the Holocene, especially for the net progradation of the Holocene deposits.

2. Sedimentation and mangroves in the study area

The coast of the Guianas benefits from the extensive mud supply of the Amazon (1200 × 10^6 tons year^{-1} (Meade et al., 1985), of which some 20% is deflected northwestwards alongshore through the Guianas to the Orinoco delta in Venezuela (Eisma et al., 1991; Fig. 2). About 40% of the initial Amazon sediment supply to the Guianas is transitorily stored in the form of extensive, shoreface-attached and, for the greater part, subtidal mudbanks (Fig. 3), oblique to the coast, beginning on the northern Amapá coast in Brazil (Allison et al., 1995, 2000). These mudbanks migrate continuously westward along the coast of the Guianas at rates of ~ 1.5 km year^{-1} (Augustinus, 1978; Rine and Gins-

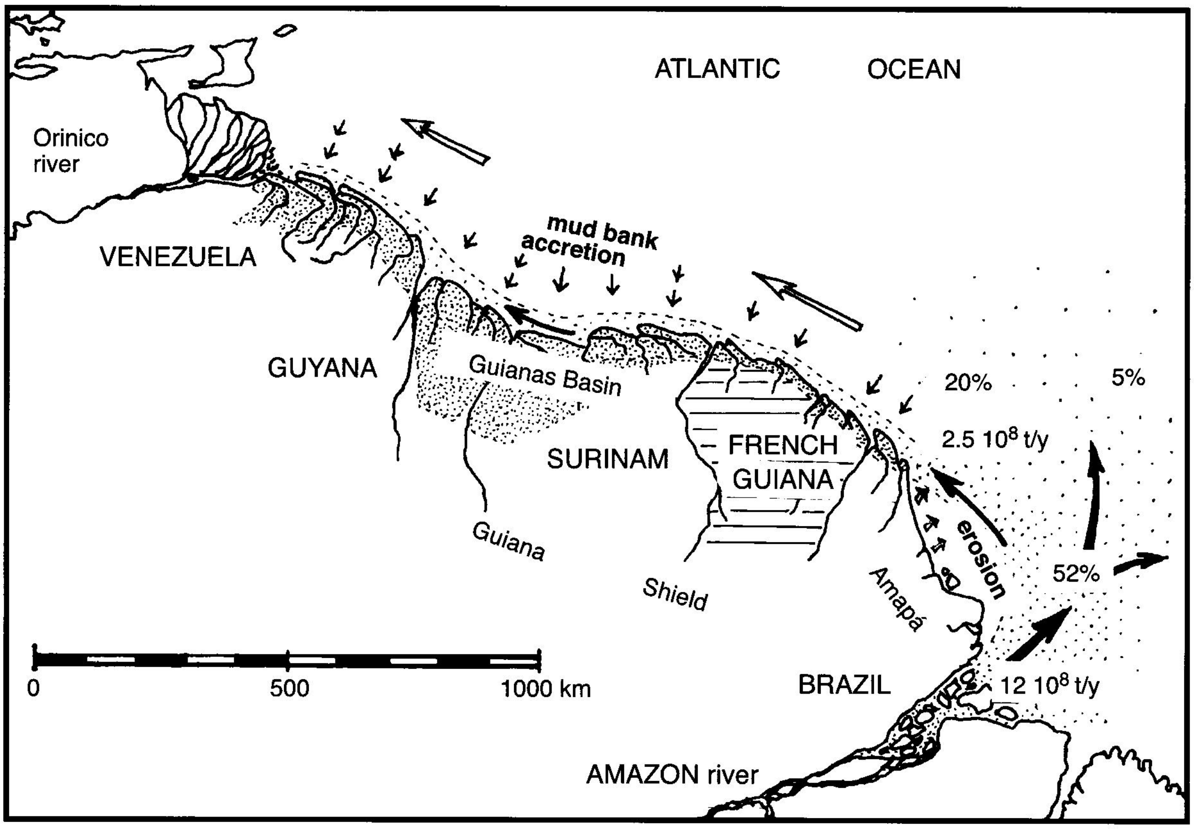

Fig. 2. The French Guiana coast belongs to the "upstream" part of a Holocene accretion belt nourished by the Amazon basin erosion. A limited part of the suspension products (20% cf. Eisma et al., 1991; 250.106 tons year^{-1} according to Allison et al., 1996) make the bulk of the littoral mud stream, 1400 km long that ends at the Orinoco delta. The present time processes cannot account completely for the development of mud capes from the northernmost Amapá State (Brazil) to the overlapping Venezuelan capes at the final sink area (Allison et al., 1995).

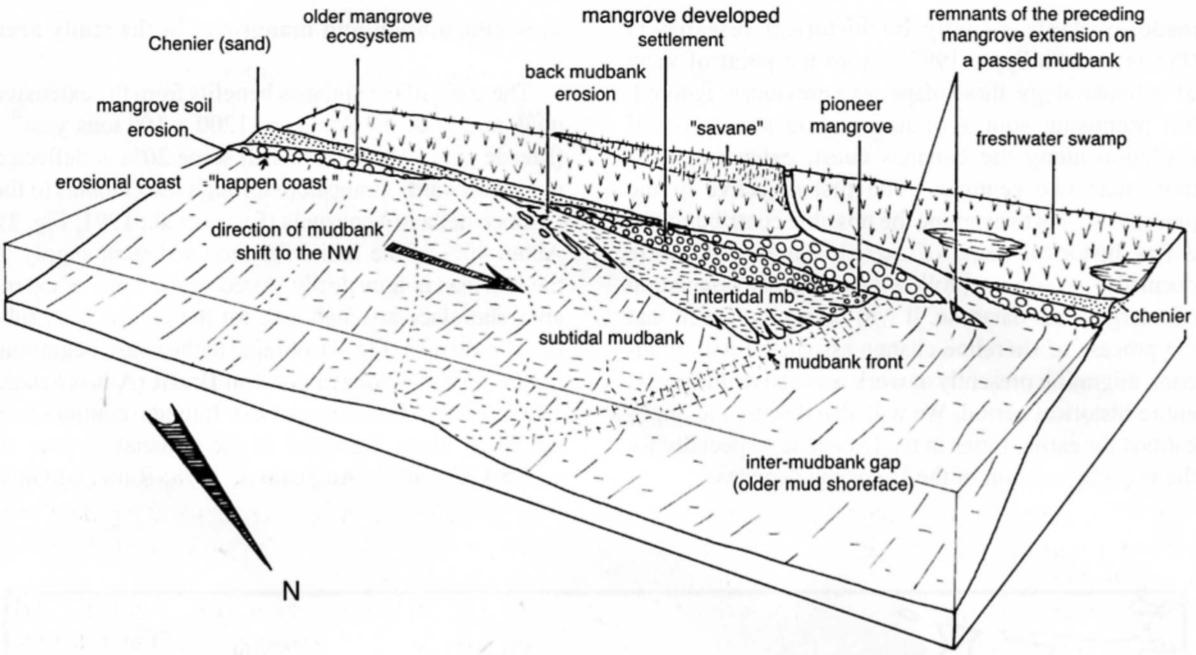

Fig. 3. Block diagram illustrating the various depositional sub-environments associated with a shifting mudbank, along the Guiana coast. The complex relations between the deposits, resulting from (at least) two successive mudbank accretion phases, certainly are oversimplified. After Augustinus (1978), Rine and Ginsburg (1985), and Froidefond et al. (1988).

burg, 1985; Prost 1990; Figs. 4–6). Their upper intertidal fringe is colonized by a mangrove ecosystem dominated by *Avicennia germinans*, associated in the pioneer settlement phase above the mean high-water level of neap tide with *Laguncularia racemosa*. *Rhizophora mangle* and *Rhizophora racemosa* are mostly found along the banks of estuaries and in a mixed forest at the rear of the *Avicennia* belt, being especially prevalent in the embayment fills such as Marais Leblond, southwest of Cayenne.

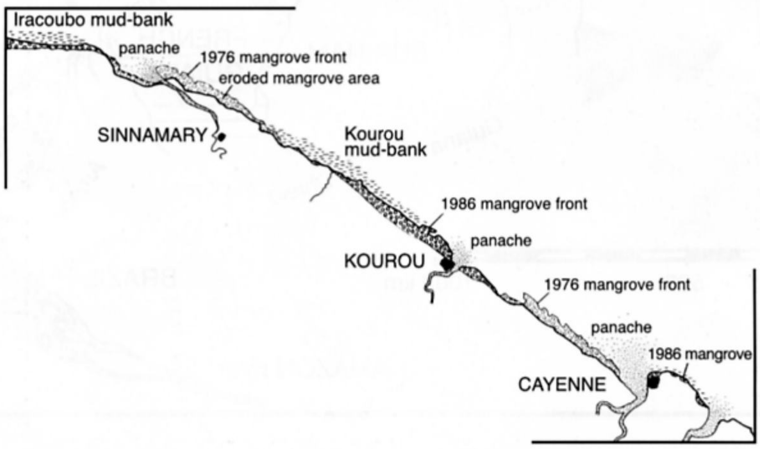

Fig. 4. Relations between the Kourou intertidal mudbank and its mangrove forest of 1986, and the adjacent erosive coast, developed at its ESE rear and in the Sinnamary coastal area, in the gap between the Kourou mudbank and the Iracoubo mudbank. A comparison between Landsat MSS, 1976 and SPOT-1 (1986) scenes. After Prost, 1990, Figs. T—14, 16.

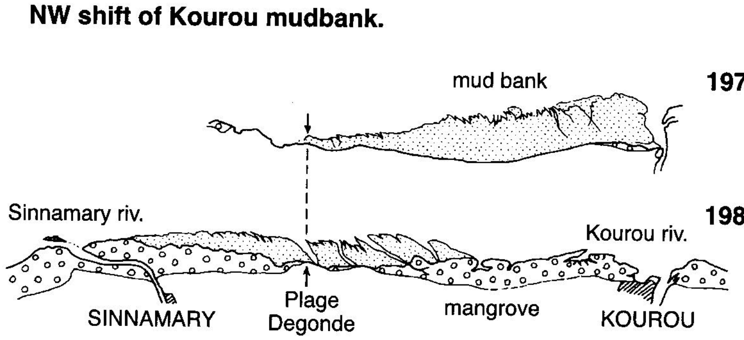

Fig. 5. An example of postponement between mudbank shift and mangrove growth and erosion. The residual mangrove area west of Kourou may deceptively suggest some net progradation, whereas it recessed before the end of the 20th century (1992, 1998 images).

Most of the mangal areas are temporary settlements on shifting mudbanks. The width of the vegetated part of the mudflats appears to be set by the river mouths, marine hydrodynamics being possibly influenced by the freshwater discharge of the estuaries. The precise location of the shoreline is difficult to establish within the intertidal mangrove forest, which merges landward into in a freshwater swamp domain, the 'pinotière', a botanical assemblage dominated by mangrove and palm trees (particularly the 'pinot', *Euterpe oleracea*). However, all the published maps have utilized the seaward limit of the *Avicennia* mangrove ecosystem to represent the shoreline, interspersed alongshore with sections of rocky and sandy shoreline (IGN, 1989, Guyane 1:500,000).

It has long been recognized (e.g., Wells and Coleman, 1981; Rine and Ginsburg, 1985) that this mud shoreface has developed in the presence of relatively high tidal/wave energy in this equatorial (4–6 °N) area. The erosive power of these marine processes are balanced, however, by the presence of high density mud suspensions that are advected ashore by the waves

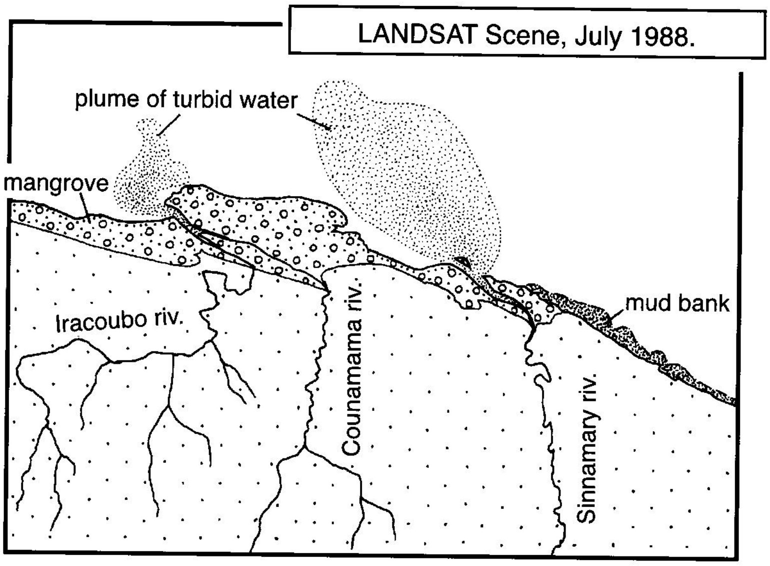

Fig. 6. Relations between mudbanks, mangrove forests and the seasonal plumes of turbid water, made by the local river discharge. After Prost, 1990. Sediment supply by the rivers appears to be a non-significant part of the local mudbank material, which conforms to the domination of Amazon mineralogy in Guianas sediments.

and tidal currents, adding to the underconsolidated mud deposits. These soft mud deposits typically accumulate along the leading edge of the mudbanks and damp wave energy, reducing their remobilization by the hydrodynamic regime. Moreover, this latitude is exempted from tropical hurricanes.

Wong (1989) revised the stratigraphic division of the coastal plain of Suriname by Brinkman and Pons (1968) and divided the Holocene into the Mana Formation (>6000 years BP) and the Coronie Formation. The latter is subdivided in three sedimentation phases, interrupted by episodes of erosion or non-deposition: Wanica phase, Moleson phase, and Comowine phase. Sediments of the Wanica phase (6000–2500 years BP) appear to be absent from the French Guiana coast. A set of six boreholes, drilled from Cayenne to Mana (Djuwansah, 1986; Tissot et al., 1988; Djuwansah et al., 1992), suggests that the coastal deposits in French Guiana may be divided into three units. The deepest core (GUY 2) near Mana is composed of a lower unit of Mara deposits, (radiocarbon ages of 7680 ± 320 and 7740 ± 640 years BP around 20 m below present sea level), characterized by a palynology dominated by *Rhizophora* pollen (65–90%). The middle unit shows a drastic change to swamp-savanna pollen, similar to the available data from Surinam and Guyana. These are

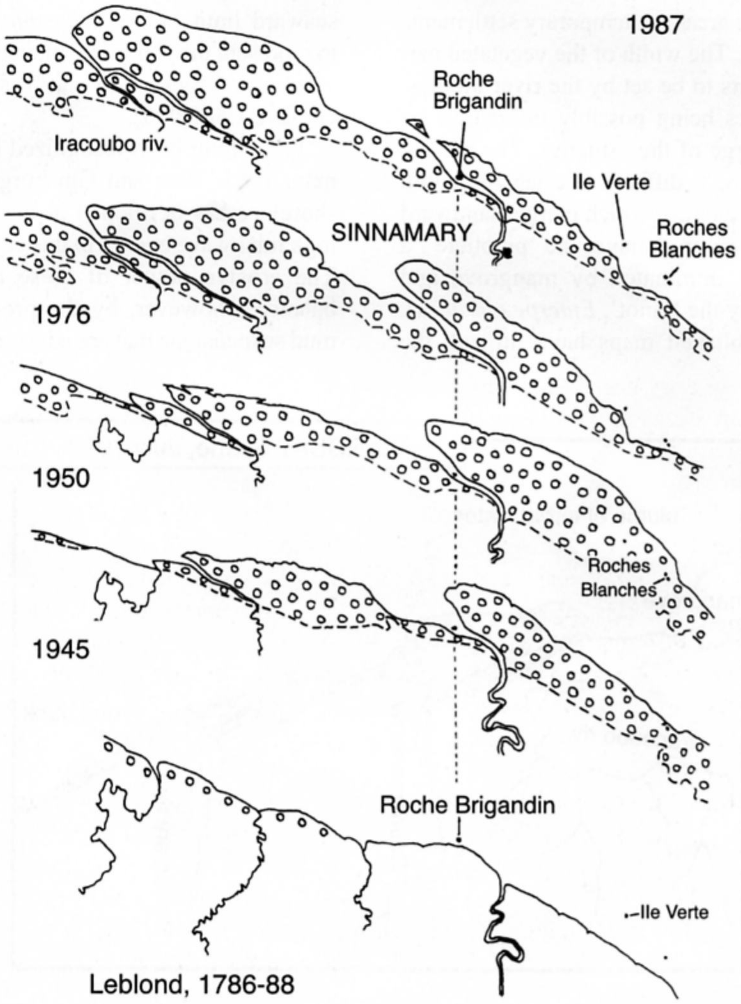

Fig. 7. Difference between the modern (1945–1987) changes of the shoreline from Crique Malmanoury (E) to the Iracoubo river (W), and the location of the shore during an ancient erosive stage (Leblond, 1786–1788, published in 1814).

referred to as Coronie deposits without any subdivision, except for the uppermost 0–4 m section, which is characterized by a large increase in *Avicennia* pollen (up to 45%). The latter unit, which includes recent sediments, is the only unit in the Holocene section with an *Avicennia*-dominated palynology, suggesting conditions during this entire interval were similar to the present seafront mangrove deposits associated with the shifting mudbank system.

The antiquity of *Avicennia* forests associated with shifting mudbanks is well established. What remains in question is to what extent the sediment deposition in this final phase of Coronie stratigraphy, characterized by a regime of migrating mudbanks with their *Avicennia* vegetation, contributed to the Holocene shoreline progradation in French Guiana? Most of the detailed sedimentological studies to date (including several papers in the present volume) are concerned with the processes presently at work in the construction and erosion of littoral deposits, associated with the alongshore shift of the mudbanks and with the changes in *Avicennia* settlement. These modern investigations, which benefited from accurate data provided by a rich collection of aerial photographs and remote sensing imagery, have resulted in a demonstration of the modern instability of the shoreline (Froidefond et al., 1988; Prost, 1990) and the associated ecological stress (Plaziat et al., 1994; Fromard et al., this volume).

A long-term progradation rate cannot be assumed from this limited period of aerial and satellite observation (~ 60 years), but the characteristic behavior of mangroves as a stabilizing and protecting agent for the shoreline favors a close relationship between the modern, extreme northwestward accretion rates registered on the Guiana mangal coast and a net progradation extending further back in time. This is the reason why we propose in this contribution to examine the value of older data, such as historical maps, which appear to give reliable information about shoreline changes, in order to check this hypothesis (Fig. 7).

3. The contribution of historical maps of French Guiana

The French settlement in what is today French Guiana began with the first pioneer Robert d'Harcourt in 1608. In 1643, French settlers and soldiers established the city of Cayenne, expelling the Dutch from the region and founding settlements at the mouth of several rivers. The need for accurate maps increased progressively. However, the first attempts give no reliable information on the extension of the mangroves because of their small scale or excessive inaccuracies in the location of the coastal features (Sanson, 1656; d'Anville, 1748; Bellin, 1763: in Decoudras, 1975). In fact, useful maps did not appear until over a century after the initiation of a large-scale colonization by the French (Tugny, 1763). Most of these early maps are hand drawn sketches and their interest comes from annotations on the drawing (Fig. 10 after de Préfontaine, 1764). A few maps of this era are presented in Figs. 8 and 9 for comparative purposes. However, fairly reliable mapping begins, in our opinion, with the general map by J.-B. Leblond, created in 1786–1788 (but published in 1814; Fig. 14). It is not suggested, however, that the improvement of cartographic compilation of maps was a progressive, regular process. Many of 19th and early 20th century maps had to be rejected because their reproduction of river courses (especially the Sinnamary river) demonstrated their inaccuracy. For this reason, only a few time intervals of depicting a reliable coastal geography are available for the period prior to 1950.

Most of the early maps were produced by professional geographers and land surveyors. However, their main interest was the land suitable for cultivation, i.e., the areas landward of the mangrove fringe sensu stricto. A detailed reconstruction of the behavior of mudbanks, including the local mangrove development, is therefore not possible. In studies of mangrove shorelines, a precise indication of the boundary between an emergent mudbank and the mangrove front is risky, except when modern GPS, detailed aerial photographs or remote sensing images are available. In our interpretations of the historical maps, therefore, qualitative changes are recognized only when precisely defined landmarks can be taken as a reference point (Roche Brigandin, river course, village).

Within these limits, we believe these historical maps are a rich source of reference for the coastal development of French Guiana during the last three centuries. The "Atlas des Départements d'Outre-Mer" concerning French Guiana (Boyé et al., 1979), although giving a good overview of old mapping and the conditions of its creation for settle-

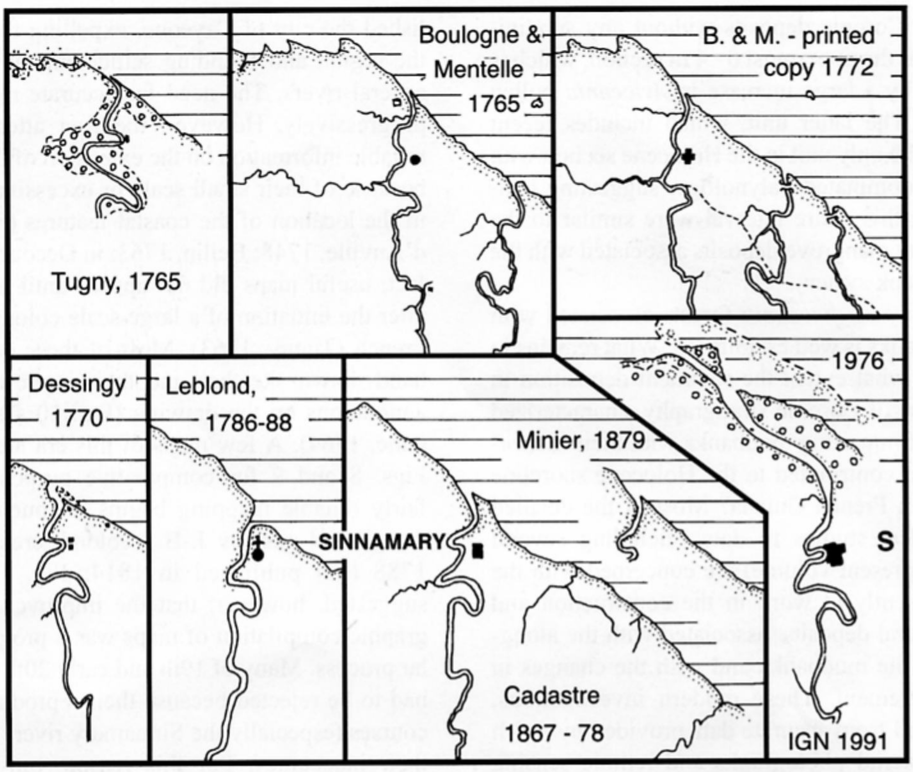

Fig. 8. Comparison of historical and recent maps reduced at the same scale, considered as reliable references for the shoreline changes close to the Sinnamary river mouth. The original unnamed settlement has developed in the city of Sinnamary.

ment purposes, does not contain maps useful for examining the sedimentological evolution of the coast. The major sources of our work are a contribution by Puaux and Philippe (1997) on the history of the Sinnamary river settlements, and color copies of maps gathered from diverse archive offices, kindly provided by Olivier Puaux. This explains the emphasis on the area around Sinnamary; however, additional maps are utilized from the area around Île de Cayenne and from the coast adjacent to the Mana river. The development of the latter area has also been documented by Augustinus (1978, Fig. 58), using Dutch historical maps of the adjacent Suriname coast.

4. Results

4.1. The Sinnamary–Kourou coastline

The best old maps were produced during the agricultural revolution of the 18th century, which resulted in a new interest in the low lands. Due to hydrological problems of the fields at higher elevations in French Guiana, the farmers had to look for swampy areas, which could easily be drained. The land surveyor Tugny, an Acadian, arrived in 1763, just before the Kourou expedition accompanied by the geographers Mentelle, Brodel and Dessingy (1763–1765, cf. Le Roux, 1992).

The preserved documentation of their study gives precise information, although the hand-drawn maps are inaccurate. They show a river mouth just below the westward bend, downstream from the camp/mission, the future site of Sinnamary village (Figs. 8 and 9). The narrow spit of the eastern riverbank may be interpreted as incipient mangrove colonization of a growing mudbank. The map drawn by Brûletout de Préfontaine in 1764 states precisely that a previous mouth of the Sinnamary River (1746) was 3–4 km to the SE of its 1763 location (Fig. 10).

It is difficult to credit the limited differences between the four maps given by Tugny (1763),

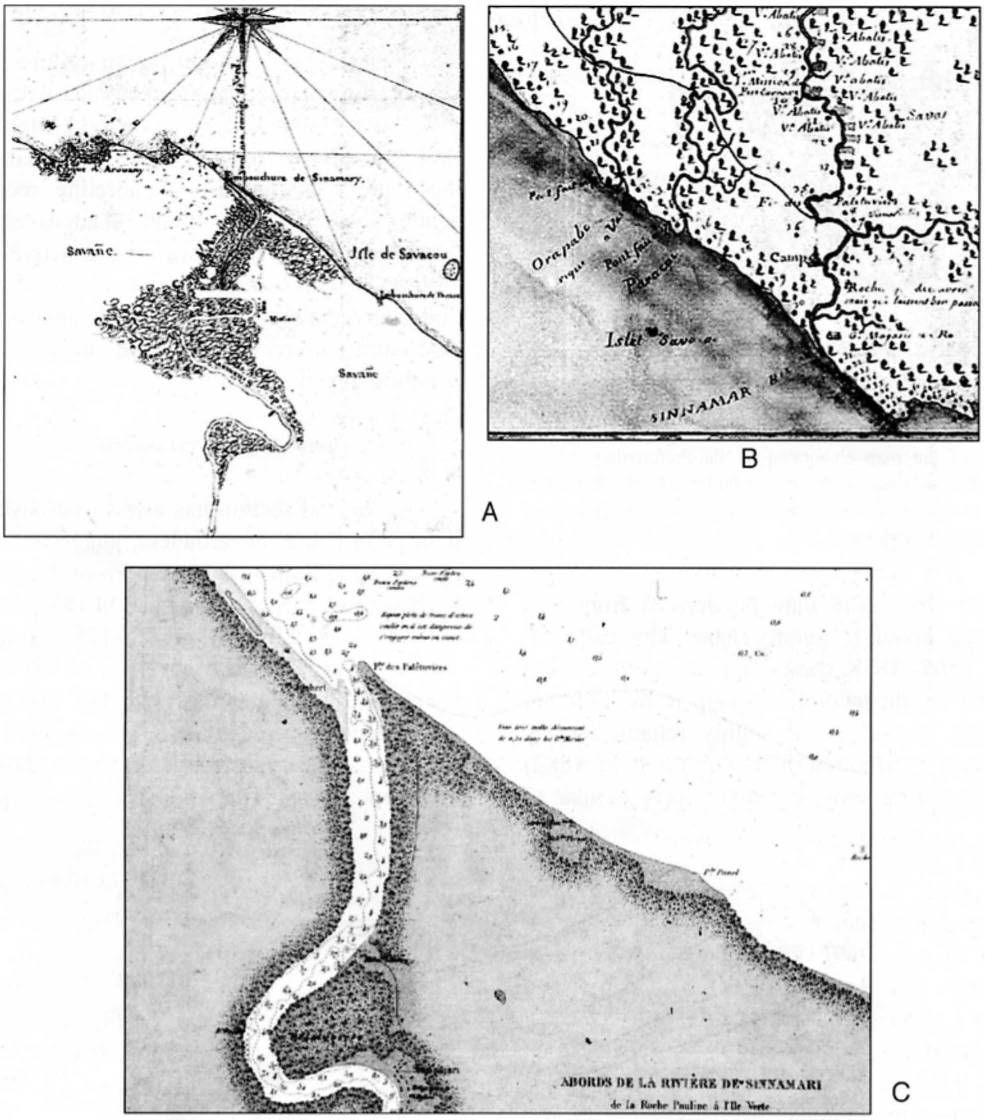

Fig. 9. Extracts of ancient maps, limited to the coast around the mouth of the Sinnamary river. A: Hand-drawn map by Tugny (1763), showing the distribution of mangrove forests. B: Part of the map of the Kourou and Sinnamari (sic) rivers elaborated by P. Boulogne (1764) to be used by Lieutenant-Colonel B. de Préfontaine. C: Hydrographic map by J. Minier, 1879 (published in 1882).

Boulongne (= Boulogne) (1764, 1772) and Dessingy (1770) as depicting marked changes in the coastline. In general, they agree on a shoreline (around 1765) adjacent to the sand ridge (chenier), which is now followed by the 'Route de l'Anse'. The inner freshwater swamp (Pripris Nango), at the rear of this sand ridge, was later drained by the Canal Philippon. Limited local shoreline erosion after 1764 is suggested by the maps drawn by Dessingy (1770) and Leblond (1786–1788). By comparison with the 20th century record of the mangrove instability, it is not possible to assume that this 40-year-long, discontinuous sampling is a complete record of the shoreline fluctuations. It only suggests that the processes of accretion and erosion were at work during this time. However, these 18th century maps do document at least one major phase of progradation.

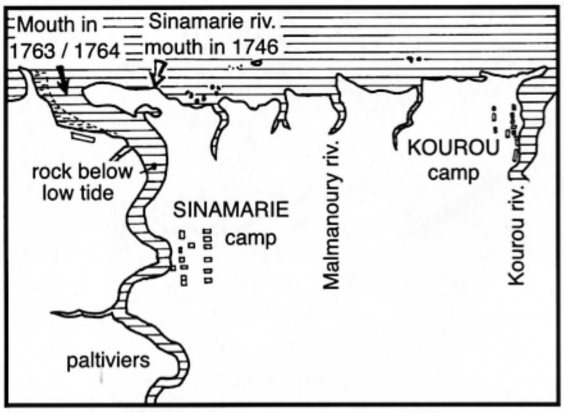

Fig. 10. Part of the map elaborated by de Préfontaine (1764), drawing after Raoul-Hénon in Puaux and Philippe (1997, Fig. 4). It is impossible to insert this sketch into the historical map sequence of Fig. 8 because of its awkwardness.

A similar conclusion may be derived from two maps created about a century later. The cadastral survey of 1867–1878 shows appreciable accretion with respect to the shoreline mapped by Leblond (1786–1788). However, the highly reliable survey by Lieutenant J. Minier (1879, published in 1882) depicts a rectilinear erosive feature, very similar to the shoreline reported a century earlier (Figs. 8 and 9C). The key information on this admiralty map is the location of the 'Pointe des Palétuviers', 1.3 km to the north of the entrance of the Canal Philippon, less than 500 m seaward from the chenier, i.e., at the same location as the shoreline recorded one century earlier. These limited changes also suggest that mud cape accretion was not as active during the 18th and 19th centuries as it appears to be since the mid-20th century. It is possible, however, that the discontinuous record may be an artifact of the mapping record.

4.2. The Mana–Maroni coastline

This coastal section has a less extensive historical map record that, nevertheless, suggests similar processes to the Sinnamary coast. From the observations by Hulst van Keulen (published in 1875) and the data collected by Leblond (1786–1788, published in 1814), an 18th century extension of the Mana mangrove cape is documented (Fig. 11). The greater part of this cape was eroded by the sea about 70 years later (De Hart, 1856), but recovered within about the next 10 years (Couy, 1865). The 1867–1878 cadastral

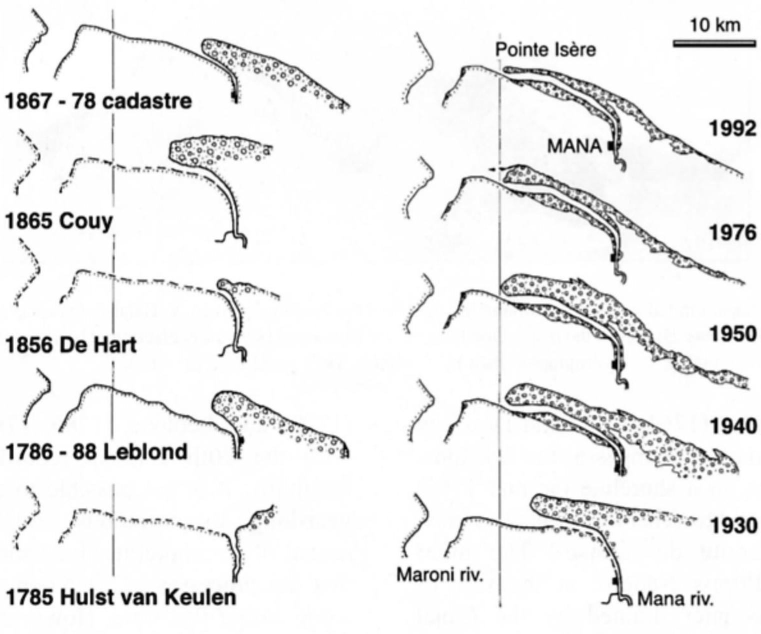

Fig. 11. The registered shoreline changes at the mouth of the Mana river, from ancient maps (left) and modern ones (right). The earliest 20th century shoreline relies on Bakhuis and De Quant 1930). Partly after Augustinus (1978).

survey (Cadastre de Cayenne, 1878) suggests another erosional phase, while the records of the 20th century demonstrate an overall westward extension of the mud cape (parallel to the coast) in spite of repeated phases of growth and erosion, modifying the width of the mangrove belt.

4.3. *Île de Cayenne*

The rocky promontory of the Guiana shield basement outcrop, between the Mahury River and the Rivière de Cayenne, protrudes seaward with respect to the prograding mangrove shoreline (Fig. 12). Its sea-facing sand beaches are segmented by a number of basement rock headlands, when mangrove development associated with the presence of mudbanks opposite this section of the coast did not cause seaward accretion beyond these indentations. During the 1954–1991 period, and especially in 1986, several sand beaches disappeared behind and beneath the muddy sediments of a mangrove forest. The only permanent mangrove area is the Marais Leblond, on the east bank of the Cayenne River, i.e., behind the main protection of the rocky hills that form the head of the peninsula around the city of Cayenne. A man-made channel (Crique Fouillée) drains this mangrove area, and joins both sides of the Cayenne promontory. Another natural channel, the Tour de l'Île River (Bras de l'Oyac in Leblond, 1814) crosses the low elevation area landward of the hilly area, justifying the Cayenne 'island' designation. The estuarine mangrove ecosystem that developed here is a mixed *Rhizophora* and *Avicennia* community, which differs from the nearly pure *Avicennia* vegetation on the mudbanks (Fromard et al., 1998). The major growth and erosion cycles observed in the growth of open-sea mangrove communities are not found in the recent vegetation records of Marais Leblond. Photos from 1945 document only a limited retreat of the coastline. An older shoreline, a few hundred meters further inland, is revealed by the change in direction of the Crique Fouillée canal. Because this corner of the canal is not

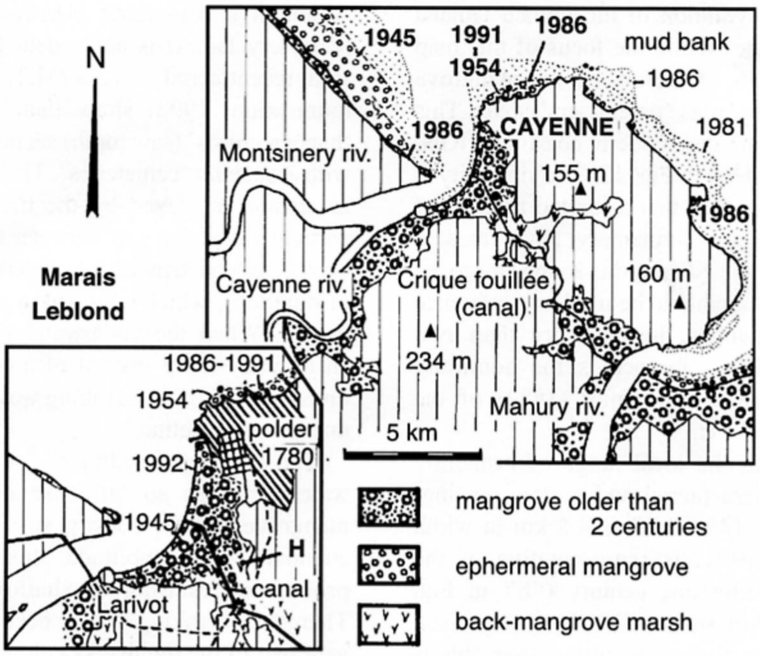

Fig. 12. Changes in the extension of mangrove forests around the Île de Cayenne promontory since the map of Leblond (1786–1788) and during the second half of the 20th century. Details of Marais Leblond, a protected mangal area initiating at least 3000 years ago (H—^{14}C date) and affected by limited progradational and erosional phases.

indicated on Leblond's map (1788), it is assumed that there has been little accretion since the early 19th century. The innermost mangrove swamp grades landward into a marsh with a few dead *Avicennia* (Baltzer et al., 1995; 'H' in Fig. 12). In this innermost zone, mangrove remains at a depth of 1 m, with a ^{14}C age of 4055 ±390 years BP (radiocarbon age; LHGI, Orsay, unpublished) indicate when the initiation of this embayment fill took place.

The main interest of this locality is therefore the preservation of a long-lasting record of a mixed mangrove ecosystem, which is unusual along this coastline. This is certainly due to its location in a highly protected environment. Apart from the stability deduced from the historical maps, the Marais Leblond area would be an excellent site to carry out a palynostratigraphical study to compare with the unique data from the GUY 2, Mana core (Tissot et al., 1988).

5. Discussion

The accuracy of the general map created by M. Leblond in 1786–1788 provides an opportunity to examine the overall evolution of the French Guiana coast, west of Cayenne. While the focus of this map was the inland courses of the rivers, the mangrove extension is clearly given as 'palétuviers' areas. This map is compared with the modern coastline (IGN, 1989, based on 1976 data) in Fig. 13. The similarity is surprisingly good, provided that a limited rotation of the shoreline around the Sinnamary River axis is accepted. Except for the SE region, it appears to be the first modern map suitable to be used as a reference for the shoreline changes during more than two centuries. Another key reference is the admiralty map elaborated in 1879 by Minier (1882) of the mouth of Sinnamary River.

It is suggested that the local range of instability recorded by the modern (aerial and remote sensing) imagery ("a" in Fig. 14), which is 4.5 km in width between 1966 and 1991, is representative of the changes recorded during one century ("b" in Fig. 14), more than 6.5 km since 1879. By comparison with the Leblond map from a century earlier, this is certainly an extreme range (cf. Fig. 13), but it points to the ephemeral nature of any land accretion beyond the outer chenier line at the century scale. This important evidence has to be considered in the study of long-term progradation rates along the French margin of the Guiana Basin.

The paradoxical opposition between extreme decennial progradation rates and long-term stability implies specific environmental factors related to the open-sea setting in the Guianas. This mangrove shoreline experiences such rapid and major changes that the postulate, repeated since the work of Davis (1940) on the Florida coast, that mangroves protect and stabilize the prograding tropical shores, must be questioned. It is a general opinion that *Avicennia* trees have a great potential to resist erosion due to their dense network of roots and pneumatophores. However, the marine erosion of the mud substrate, removing simultaneously the subtidal and the intertidal bank deposits by a retrogressive process, resulting from the migration of the mudbanks, leaves the *Avicennia* forest unprotected. With growing water depth in front of the native mangrove forest, waves increase in energy and become an increasingly efficient tool against the upper intertidal substrate. It is not necessary that this catastrophic shoreline erosion be preceded by a decay of the forest through other factors. Although it sometimes happens that a dying stage (cemetery facies) is antecedent to the shoreline erosion, recent aerial surveys (M.T. Prost, personal communication, 1992) show that most of the erosive 'happen coasts' (saw tooth) sections are not associated with *Avicennia* 'cemeteries'. Therefore the crucial role in erosion is played by the marine hydrodynamics, particularly in the gap between two successive mudbanks, several tens of kilometers long (several years of duration), which completely reshape the shoreface profile. When the underwater morphology becomes an ordinary ramp instead of a convex bank (Augustinus, 1978, Fig. 9), breaking waves directly attack the mangrove shoreline.

The suspended sediment concentration of coastal water also has an influence on the erodibility of mangroves. High density suspensions (fluid mud) attenuate wave amplitude, thus favoring silting up processes, resulting in shallowing water depths. Therefore, breaking waves occur far from the emergent part of the mudbanks colonized by an *Avicennia*-dominated mangrove. Conversely, low suspended sediment concentrations characteristic of interbank stages do not moderate the wave energy, and when

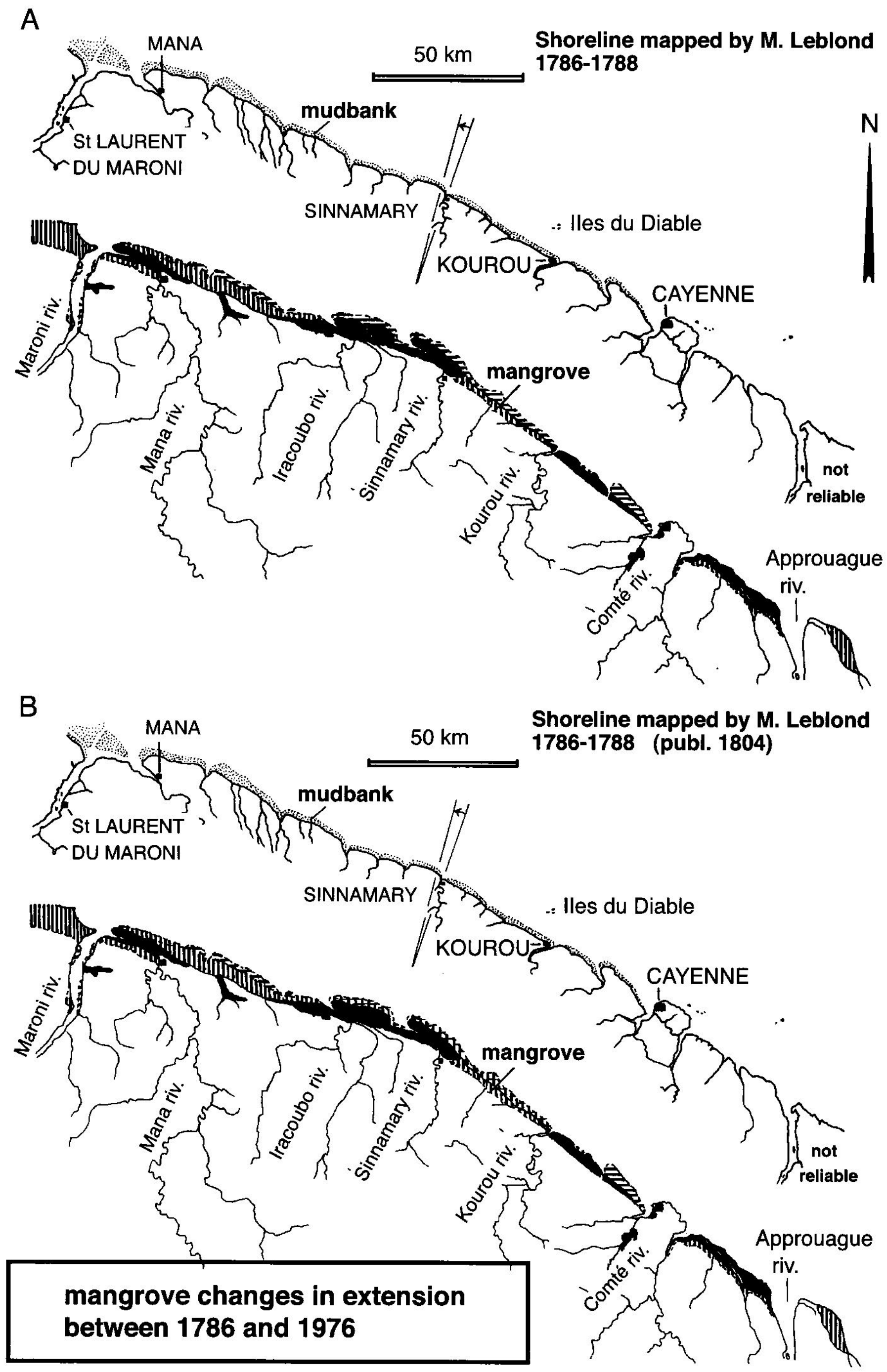

Fig. 13. A comparison between the general map by Leblond (1814), drawn from data collected in 1786–1788 (with the necessary angular rotation for the western part) and the modern, IGN map (1989, based on 1976 data). In black: The modern mangrove extension; vertical hatches cover the accreted areas between 1786 and 1976; horizontal hatches, the cumulative gained and lost mangrove areas since 1976.

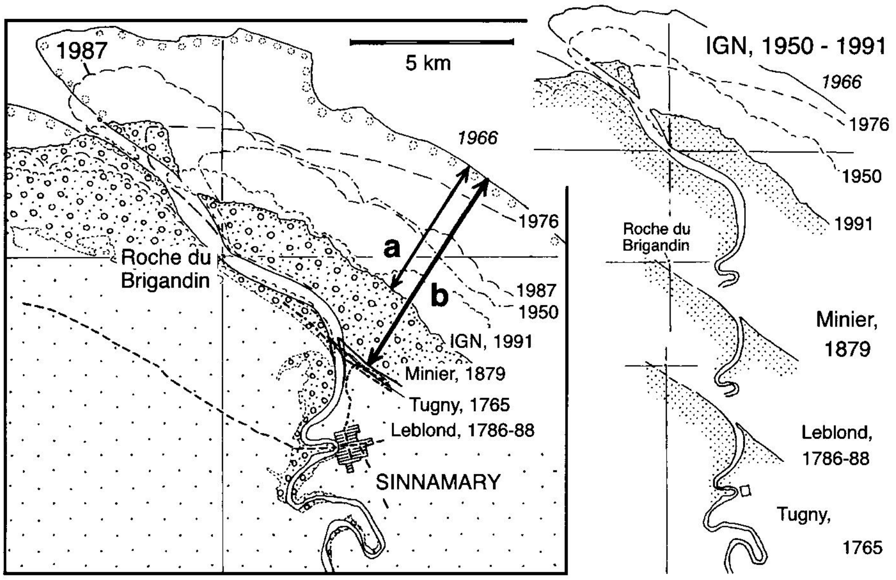

Fig. 14. A comparison between different maps of the mouth of the Sinnamary river, from the middle 18th century to the more recent major extension of the mangrove forest (1966), followed by a rapid erosion (1991). (a, b) Coastal progradation at different time scales: decennial and centennial, respectively (comment in the text).

the subtidal protection of a mudbank has shifted a few kilometers downstream the long-shore Guiana Current, the substrate of this exposed mangrove forest becomes excessively unstable facing the same ocean energy.

The progradation rates of mangrove shorelines are generally assumed to be among the highest of the seashores. This certainly results from the frequent association of mangrove forests with major deltaic output of suspended material, settling down near the mouth of the distributary channels. For example, in the protected settings of the Malacca Strait, Eastern Sumatra, the progradation rate on the delta front of the Musi River during the 20th century is estimated around 10–20 m year^{-1} (Chambers and Sobur, 1977), while the calculation derived from historical maps (Obdeijn, 1941, 1942) would suggest a 100 m year^{-1} rate. In the same Musi River delta system, the long-term result (for a marine sample about 3000 years old, 38 km from the ecologically equivalent modern station) is 13 m year^{-1} (Plaziat et al., 1996). This is probably one of the highest regional rates of definitive accretion.

In the special case of the exposed coast of the Guianas, the distance from the source, the Amazon River, to the incipient mud deposition on the Brazilian shore is more than 300 km. Moreover, the mudbank contribution to the shoreline accretion is not a continuous but a more or less reversible process due to the shifting of mudbanks from Cape Cassipore (N. Brazil) to the Venezuelan Orinoco delta. There, the suspended Amazonian material ends its alongshore translation and fills the largest littoral plain built during the Holocene (Allison et al., 2000). In the intermediate location of the French Guiana coast, the only significant progradation rates concern the westward extension of mangrove mud capes, deflecting the river mouths to the WNW during the growth stage of the mudbanks, shifting at a rate up to 2000 m year^{-1} (Froidefond et al., 1988). The seaward aggradation rate (to the NNE) is much lower, reaching a maximum of 240 m year^{-1} (Charron et al., 1992). This is a misleading rate, however, in that there is almost a balance between net loss and gain for the whole coastline (Froidefond et al., 1988). The general trend established with the help of historical maps, moreover, suggests a quasi-equilibrium at the centennial time scale (i.e., an absence of a real land accretion beyond the line of the last chenier). This is possibly the answer to the question of the major change in palynology observed in the Mara (GUY 2) core: this stabilization line probably delineates an older (*Rhizophora*) and a modern (*Avicennia*) Holocene belt, separated by an erosional surface in the core. A campaign of ^{14}C dating would be advisable in order to check this hypothesis. This interpretation agrees with Pujos et al. (1996) that suggested three mud units are recognizable since 3000 years BP, separated by sand deposits (including cheniers), based on clay mineral evidence. These sand deposits are associated by these authors with a drier climate on the Amazonian basin, the last climatic event (end of unit 2) beginning around 1000 years BP while the preceding one (end of unit 3) would have started around 1700 years BP. The higher kaolinite–smectite content of the two older units matches with the core analyses of Djuwansah et al. (1992). Most of the Holocene plain would therefore appear to be older than 1000 years and would reflect environmental conditions somewhat different from the modern ones, which are illustrated by the shifting mudbanks. This may suggest that the large meander pattern associated with all the rivers that cross the Holocene alluvial plain up to the landward boundary of the cheniers (Fig. 1) may be representative of past climates rather than the modern one.

To sum up the interpretation of the complex Holocene sequence, we may envisage that the most recent phase of mud sedimentation, connected with the migrating mudbanks, may relate to a climatic change as well as to anthropogenic soil destruction in the Amazon basin. However, the deciding influence of sea-level rise during the 20th century may also be under consideration. The present lack of precise chronology let these hypotheses open to future discussions.

6. Conclusion

The rapidly evolving *Avicennia* mangrove ecosystem on the exposed oceanic coast of French Guiana has been considered as an exception at a global scale. Local progradation rates reported for the last decades certainly are astonishingly rapid, although they can be explained by the rapid shift of the mudbank substrate (the westward rate of accretion being actually roughly equal to the simultaneous erosion of the rear of each mudbank). Most of this instability may be explained by the location of the French Guiana coast in the protruding, upstream part of the Guiana basin (Fig. 2). However, the degree to which net seaward progradation is taking place remains uncertain. The historical maps of the shoreline demonstrate that the high rates of accretion and erosion associated with mudbank passage, which follows a ~ 30-year cycle today, extends at least as far back as the historical period, i.e., the last two and a half centuries. The onset of this cycle is still uncertain. As the *Avicennia*-dominated mangroves are not documented until the uppermost Holocene sequences, it is suggested here that the modern regime of tidal forest growth on shifting mudbanks was not necessarily active earlier in the Holocene and during previous (Quaternary) progradation phases of the French Guiana shoreline.

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